Accuracy Evaluation of SRTM (used in Google Earth) by Comparison with National Topographic Maps (1:50,000) in North of Iraq

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Abstract

Digital Elevation Models (DEM) of a region can be generated from stereo pairs of satellite images , enables the work to improve decision-making, take faster and more informed action based on geospatial information,but some times these data may be unavailable or expensive for students to use it in a mapping and preliminary design. Today Google Earth Enterprise helps organizations with amazing speed, full context, imagery and other geospatial data DEM with incredible resource for downloading topo data, makes that information accessible to all employees who need access via data with no cost. Google earth Geospatial data DEM it been lunched from (SRTM) NASAs Shuttle Radar Topography Mission. The aim of our study is to assess the quality of the GE-SRTM-DEM derived from the X-SAR system and comparing it with selected national topographical maps for north of Iraq with scale 1:50,000 . An important aspect of the study is to be able to conclude on the real relevancy of the GE-SRTM product compared to the already existing products, for instance is it to be considered as a new global topographic reference or should it be only limited to some applications such as GIS-projects, hydrological, mapping, even it can be used in preliminary design stage for projects.

Keywords: DEM, GE, SRTM, Geospatial, Georeferencing, TIN.

تقيم دقة الـــ SRTM (المستعمل في جوجل ايرث) بمقارنتها مع الخرائط الطبوغرافية بمقياس 1:50000 في شمال العراق

الخلاصة

النماذج الرقمية للارتفاعات DEM لمنطقة ما يمكن تكوينه بواسطة زوج مجسم من صور الأقمار الصناعية ،وبدوره يساعد بتحسين اتخاذ القرارت للاعمال ، واتخاذ إجراءات بسرعة أكبر وذلك بالاعتماد على المعلومات المكانية ، ولكن في بعض الأحيان قد تكون هذه البيانات غير متوفرة أو باهظة الثمن للطلاب لعمل الخرائط او استعمالها في التصاميم الاولية. في الوقت الحاضر قامت جوجل ايرث بتزويد المؤسسات وبسرعة مذهلة ، بكل البيانات ، والصور وغيرها من البيانات الجغرافية المكانية DEM وبمخزون هائل لتحميل البيانات الطبوغرافية المطلوبة ، بحيث يجعل تلك المعلومات متاحة لجميع المستخدمين الذين يحتاجون إلى الوصول إلى البيانات وبدون أي تكلفة. البيانات المكانية لجوجل ايرث DEM ماخوذة من (SRTM) مكوك ناسا للاستكشافات الطبوغرافية. الهدف من هذه الدراسة هو لتقييم دقة البيانلت DEM SRTM المستمدة من نظام X-SAR الموجودة في برنامج جوجل ايرث ومقارنتها مع الخرئط الطوبوغرافية المنتقى لشمال العراق بمقياس 1:50000. الجزء المهم من هذه الدراسة هو استنتاج الصلة الحقيقية للبيانات SRTM الموجودة في GE مقارنة مع البيانات المزودة من مصادر اخرى ، في الوقت الراهن يعتبر بمثابة مرجعية عالمية جديدة للطوبوغرافية أو أن يكون

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مقصورا فقط على بعض التطبيقات مثل مشاريع نظم المعلومات الجغرافية ، الهيدرولوجية ، ورسم الخرائط ، وحتى يمكن استعماله في المراحل الأولية لأعمال التصاميم للمشاريع.

Introduction

For a long time, and often until now, getting elevations for design and for updating topographic maps was an analogue process requiring heavy aerial campaigns and time-consuming human processing. It explains why, in a lot of countries and especially the poorest, the updating of current maps can not be done, and as a result the lack of recent topographic information is a barrier for the development of these countries. It is usually assumed that less than a third of emerged land all over the world is mapped with fairly recent topographic maps و consequently the need in map updating is huge and urgent [1]. After the digital revolution and the beginning of computer-assisted map processing, geographic information, construction design's survey, entered a new era a few years ago: with the arrival on the public market of very-high-resolution digital satellite, what I call the Satellite Revolution, which in theory allows high-scale maps and extract elevation data of everywhere to be made while remaining seated in one's office. This revolution in geographic information is in fact a combination of many factors such as increasing powerful computers at a cheaper price, more and more efficient processing software, the availability of very-high-resolution satellite images as mentioned previously. The result of this convergence of positive facts is a number of using satellite elevation data with minimum cost in design stage and mature cartographic solutions to update existing maps, rapidly and cheaply. In this study we submitted a comparison of the national topographical maps and the DEM data available in Google earth, to evaluate the variant between both of them [2], the process is done by using ArcGIS package which been an evolutionary method shown to provide greater flexibility in its ability to adapt to incorporate/ utilise available evidence/knowledge and develop [3].

Google Earth Enterprise

Google Earth Enterprise helps organizations with imagery and other geospatial data make that information accessible and useful to all employees who need access via an intuitive, visual, and fast application. Visualize, explore and understand information on a fully interactive 3D globe or 2D browser based maps. Enable your workers to collaborate, improve decision-making, and take faster, more informed action based on geospatial information. Google Earth Enterprise gets rich geo-data to your users with amazing speed and full context. With over 400 million product activations worldwide, Google Earth is a familiar, with an easy-to-use interface product that helps users get up and running quickly without extensive training [4]. Google earth Specifications can be summarized as:

- Low cost/Free
- Low resource/high disreputability
- Interactive, visual
- Low technical skill
- Good for community use
- Less technically intimidating
- Accommodates reasonable amount data

• Rewards streamlining of story
• Rewards tight scripting
• furnished with ground DEM

Sources of Data in Google Earth

Google Earth uses digital elevation model (DEM) data collected in February 2000 by NASA's Shuttle Radar Topography Mission (SRTM) [5]. A free DEM of the whole world available for most of the globe and represents elevation at a 3 arc-second resolution (around 90 meters). It has also been developed at 1 arc-second (30 m) resolution, but this has only been declassified for United States territory. The limitation with both datasets is that they cover continental landmasses only, and SRTM does not cover the polar regions and as mountain and desert no data (void) areas [5] .The most usual grid (raster) is between 50 and 500 meters. In gravimetry e.g., the primary grid may be 50 m, but is switched to 100 or 500 meters in distances of about 5 or 10 kilometers. Many national mapping agencies produce their own DEMs, often of a higher resolution and quality, but frequently these have to be purchased, and the cost is usually prohibitive to all except public authorities and large corporations.

Test Area

The comparison study has been made in the northern of Iraq and achieved in four sites each was about (70km by 50km) in different places see (fig.1 & fig.2). The topography of the selected area was varying between flat and mountains terrain. As a reference we used topographic map which produced and published by the defence mapping agency Hydrographic/Topographic center ,Washington ,DC in 1990 with scale 1:50,000 these was available for north of Iraq only, it was in BMP (BITMAP) format and required for georeferencing which has been achieved on all photos, this include aligning geographic data available on the photos to a known coordinate system so it can be viewed, queried, and analyzed with other geographic data. Georeferencing may involve shifting, rotating, scaling, skewing, and in some cases warping, or rubber sheeting, the georeferencing data which been depended on, was the longitudinal(λ) and latitude(φ) coordinates which is illustrated in the corners of topographic maps (fig.3).

Data acquisition and processing

Before lunching data, extracting the study area should be set in Google earth to 1st area (fig.1) and then the extracting data phase from Google earth been started using kimler software [6] , which help to make a link between Google earth and ArcGIS by extracting the image and data to ArcGIS for the specified area in Google Earth, the downloaded points represented as geographic coordinates (φ , λ) format. It was necessary to use transformation tool (fig.4) for the points to transform the coordinates from geographic coordinates (φ , λ) into grid coordinate system WGS_1984_UTM _Zone_38N as shown (table.1) the columns on the left of the table-1 represent, in ArcGIS, the downloaded point from Google earth in geographical world coordinate , and the columns on the right represents the transformed coordinate to the Zone 38N in Universal Transverse Mercator (UTM. The next stage is generating DEM ,the result will be represented as triangulated irregular network (TIN) (fig.5) and then to produce contour map with required interval in order to use it for the comparison with the topographical maps (fig.6) , the same process mentioned above has attained on the other 2nd, 3rd and 4th areas which was previously illustrated in (fig.1) .

Map and TIN Contour Lines Matching

In this stage the topographic map scale 1:50,000 has to be accurately registered to the same eference system which was indicated on the maps (fig.3) using georeferencing, this process includes assigning a coordinate system that associates the data with a specific location on the earth. Regarding the GE-SRTM there was no need for GCP (Ground Control Point) to be used for georeferencing because the SRTM data which been used in Google Earth was already rectified and registered to the world coordinate system [8], the next step is by evaluating the difference of topographic map contour lines and contour line generated from google earth elevations (fig. 6,7,8 & 9) using ArcGIS overlying utilities to lay contour lines which been created previously from TIN with a registered 1:50,000 scale topographic map, then examine and measure the variances in the test area. From the inspection on the focused area as shown in (fig.10) the variance can be noticed clearly since the topography of the area is flat and the average shifting reaches to 330m, while in mountains 2nd ,3rd and 4th areas the difference was very small as illustrated in (fig.11),(fig.12)and (fig.13),even in most areas the variance reaches to less than 15m but this variance not applicable in gaps and void because these pointes been interpolated to provide unavailable data .

Conclusions

This paper presents the comparison results to evaluate the accuracy of the GE height data and topographic 1:50,000 maps on some of our selected sites in north of Iraq. This study assesses the success of GE-SRTM-DEM of 3 arc-second resolution that is freely available and rectified via the Internet through Google Earth. The accuracy assessment is performed by comparing GE-SRTM-DEM with topographic map scale 1:50,000. The topographic map data which produced by defence mapping Agency in 1990 used in 4 areas each covers about (70km by 50km) located in different regions of North of Iraq. Totally, more than 2.5 million points were been extracted from Google earth and exported into ArcGIS to start comparison process. The result between Google Earth DEM and topographical maps was variant there was a systematic elevation shift between SRTM and 1:50,000 maps occurred in flat areas (fig.10) the average shifting was about 330m and the variant was decrease in mountains and hilly area it was about 15m and less in some places even it was matching with map contour lines (fig.10,11,12&13), but this displacements are not applicable in gaps and voids because these pointes been interpolated to provide unavailable data therefore GE-DEM it does not represent the natural ground 100%. Our conclusion is that GE-DEM is good for an indication of height/slope and aspect of land and it not need for fixing ground control point, but since the resolution is 90m the voids and gaps will be interpolated through this interval therefore it is not sufficient for detailed design of any sort, as a brief, it is recommended to use Google Earth DEMs in:

- modeling water flow or mass movement .
- rendering of 3D visualizations.
- creation of physical models
- terrain analyses in geomorphology and physical geography
- Geographic Information Systems (GIS)
- Preliminary Engineering and infrastructure design
- Line-of-sight analysis
- Base mapping
- Flight simulation
- Surface analysis
- Auto safety / Advanced Driver Assistance Systems (ADAS)

References

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Table (1) List of download points from Google Earth to ArcGIS and transferred to grid UTM (a)Points in geographic coordinate system (b) Points in grid UTM system.

id	x	y	z
0	42.36214428	36.02235145	231.6755723
1	42.36214327	36.0229059	231.7010444
2	42.36214223	36.02346039	231.7264934
3	42.36214123	36.02401482	231.7519655
4	42.36214021	36.02456927	231.7774145
5	42.36213917	36.02512375	231.8028866
6	42.36213816	36.02567818	231.8283588
7	42.36213714	36.02623262	231.8538077
8	42.36213612	36.02678705	231.8792799
9	42.3621351	36.02734148	231.904752
10	42.36213408	36.02789589	231.930201
11	42.36213305	36.02845033	231.9556731
12	42.36213204	36.02900473	231.9811453
13	42.36213102	36.02955914	232.0065942
14	42.36213001	36.03011353	232.0320432
15	42.36212897	36.03066795	232.0575153
16	42.36212796	36.03122233	232.0829875
17	42.36212695	36.03177672	232.1084364
18	42.36212591	36.03233112	232.1339086
19	42.36212491	36.03288548	232.1593575
20	42.36212388	36.03343986	232.1848297
21	42.36212286	36.03399424	232.2102786
22	42.36212169	36.0345485	232.2106958
23	42.36212051	36.03510276	232.2109508
24	42.36211917	36.03565697	232.2112057
25	42.36211783	36.03621116	232.2114839
26	42.36211742	36.03676582	232.3534233
27	42.36211723	36.0373206	232.5301522
28	42.36211704	36.03787539	232.7068579
29	42.36211685	36.03843015	232.8835868
30	42.36211666	36.03898492	233.0602926
31	42.36211647	36.03953968	233.2369983
32	42.36211626	36.04009445	233.4137272
33	42.36211609	36.04064918	233.5904098
34	42.36211589	36.04120393	233.7671155
35	42.36211571	36.04175865	233.9438213
36	42.36211553	36.04231336	234.1205038
37	42.36211531	36.04286811	234.2972096
38	42.36211514	36.04342279	234.4738921
39	42.36211494	36.0439775	234.6505979
40	42.36211474	36.04453222	234.8272805
41	42.36211455	36.04508689	235.003963

id	x	y	z
0	262297.3314	3989646.872	231.6755723
1	262298.9073	3989708.391	231.7010444
2	262300.4805	3989769.915	231.7264934
3	262302.0571	3989831.433	231.7519655
4	262303.6327	3989892.952	231.7774145
5	262305.2054	3989954.475	231.8028866
6	262306.7815	3990015.992	231.8283588
7	262308.3564	3990077.51	231.8538077
8	262309.9313	3990139.028	231.8792799
9	262311.5065	3990200.545	231.904752
10	262313.0819	3990262.061	231.930201
11	262314.6557	3990323.579	231.9556731
12	262316.2313	3990385.094	231.9811453
13	262317.8069	3990446.608	232.0065942
14	262319.3826	3990508.122	232.0320432
15	262320.9564	3990569.638	232.0575153
16	262322.5319	3990631.15	232.0829875
17	262324.1075	3990692.663	232.1084364
18	262325.6811	3990754.177	232.1339086
19	262327.2578	3990815.687	232.1593575
20	262328.8326	3990877.198	232.1848297
21	262330.4072	3990938.71	232.2102786
22	262331.9683	3991000.209	232.2106958
23	262333.5289	3991061.709	232.2109508
24	262335.0747	3991123.203	232.2112057
25	262336.6205	3991184.694	232.2114839
26	262338.2518	3991246.235	232.3534233
27	262339.9032	3991307.79	232.5301522
28	262341.5542	3991369.345	232.7068579
29	262343.2062	3991430.897	232.8835868
30	262344.8576	3991492.45	233.0602926
31	262346.5084	3991554.003	233.2369983
32	262348.1585	3991615.556	233.4137272
33	262349.8111	3991677.105	233.5904098
34	262351.4613	3991738.656	233.7671155
35	262353.1138	3991800.203	233.9438213
36	262354.7656	3991861.75	234.1205038
37	262356.4147	3991923.3	234.2972096
38	262358.068	3991984.844	234.4738921
39	262359.7185	3992046.39	234.6505979
40	262361.3682	3992107.938	234.8272805
41	262363.0201	3992169.481	235.003963

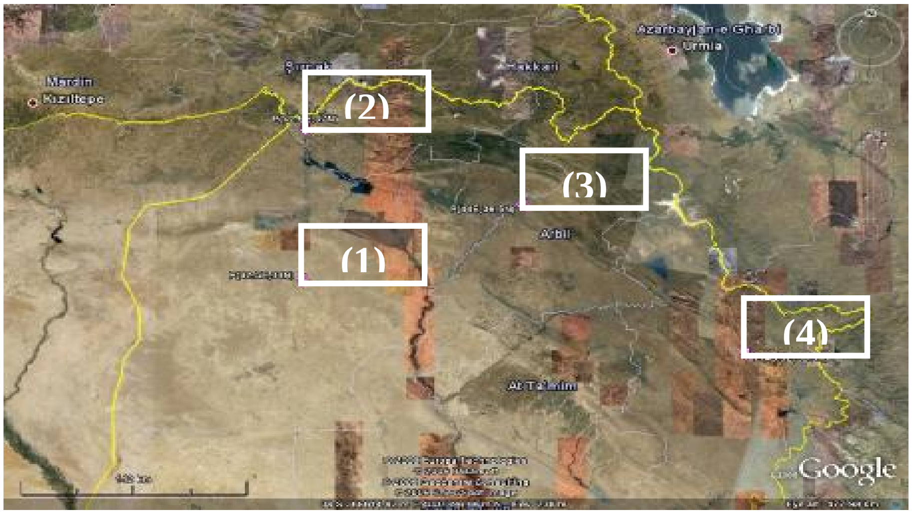


Figure (1) Study areas indicated on Google Earth software

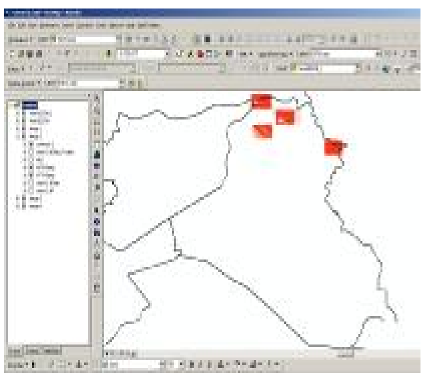


Figure (2) Four study areas shown in ArcMap software

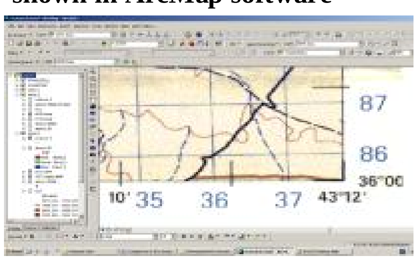


Figure (3) Geographic Coordinate system indicated in Corner of the topographical map

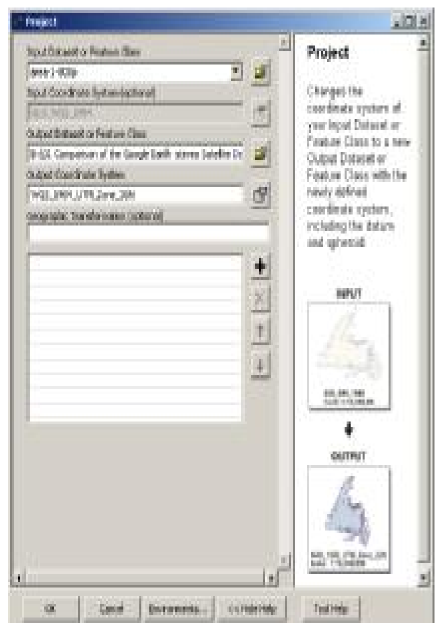


Figure (4) Transformation tool in ArcGIS software to convert from Geographical coordinate system to UTM system

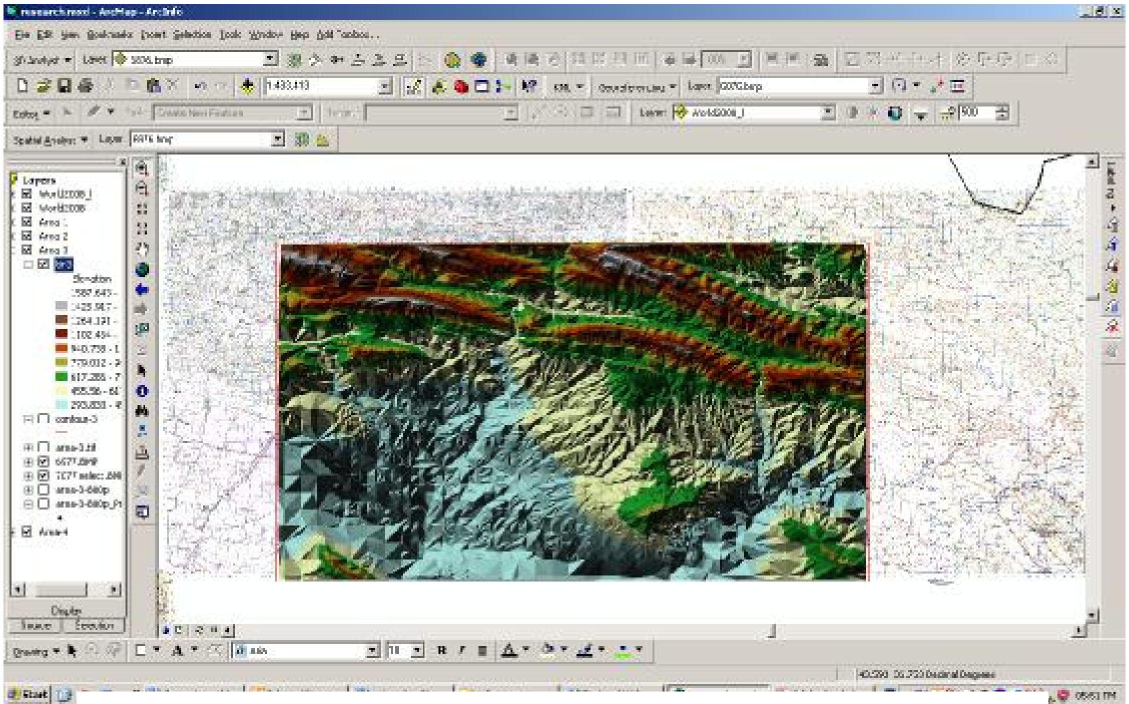
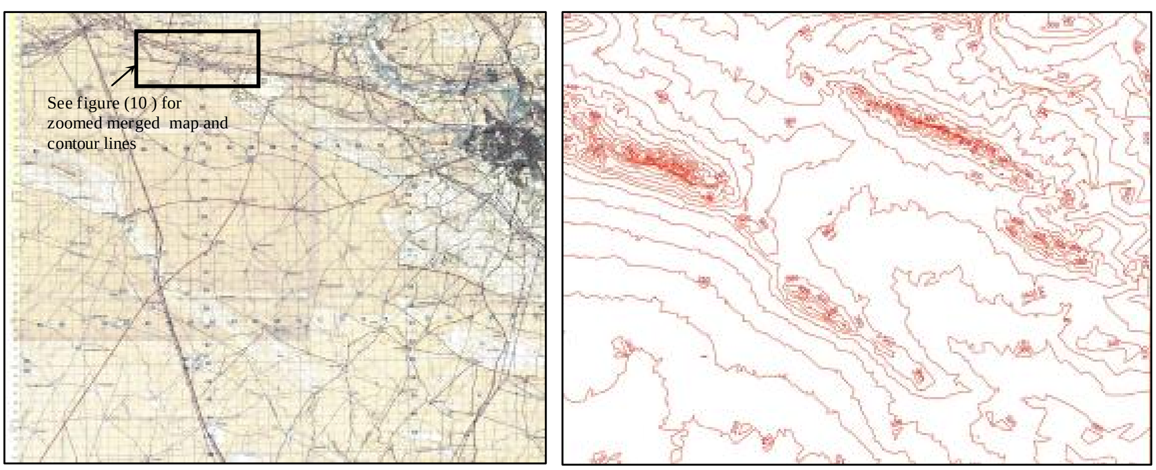


Figure (5) Triangulated Irregular Network (TIN) created for the 3rd study area.



(a) (b)

Figure (6) First area topographic map and its contour map

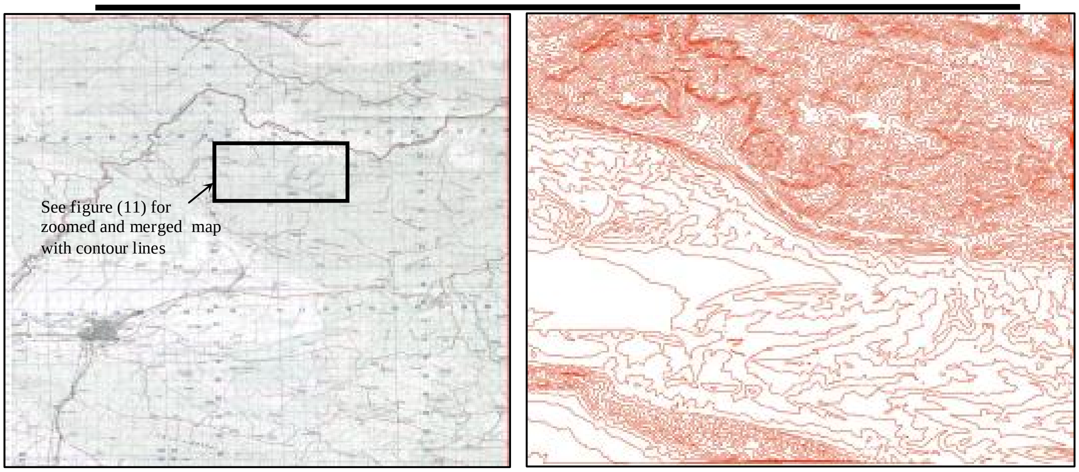


Figure (7) Second area topographic map and its contour map

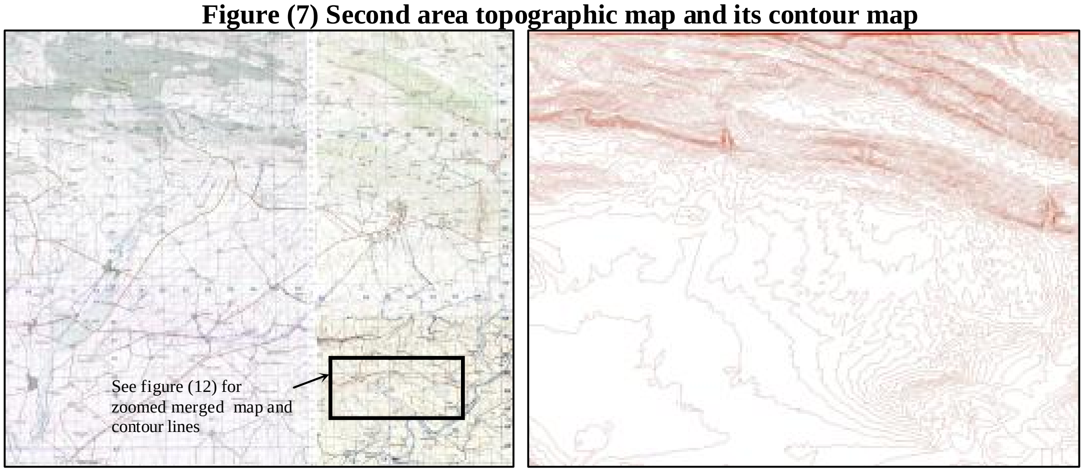


Figure (8) Third area topographic map and its contour map

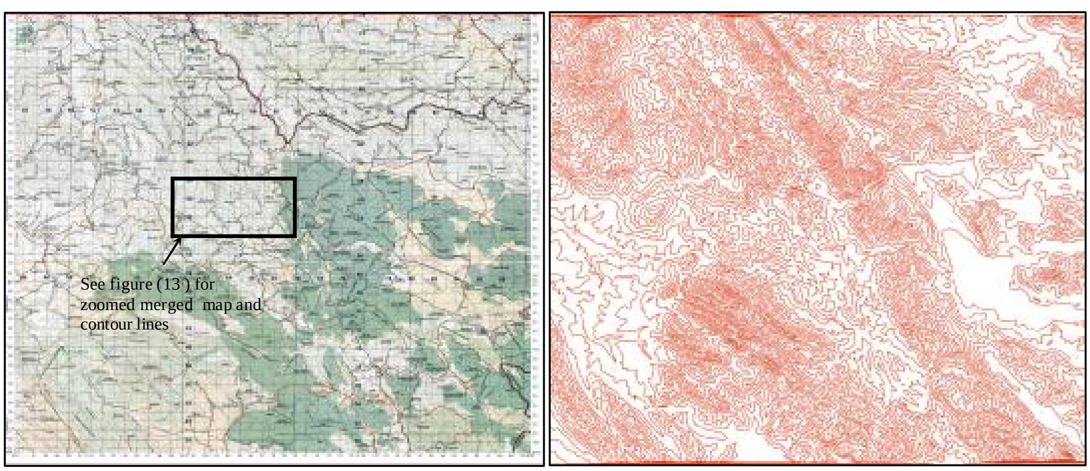


Figure (9) Fourth area topographic map and its contour map

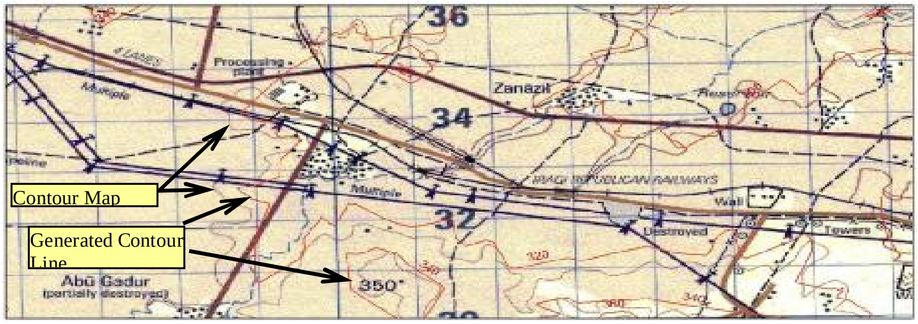


Figure (10) Zoomed part of 1st test area illustrating the generated GE contour lines (red) overlaid on topographic map (1:50,000).

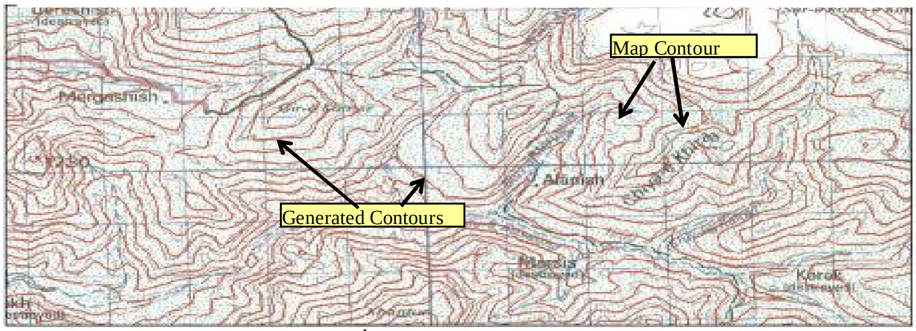


Figure (11) Zoomed part of 2nd test area illustrating the generated GE contour lines (red) overlaid on topographic map (1:50,000).

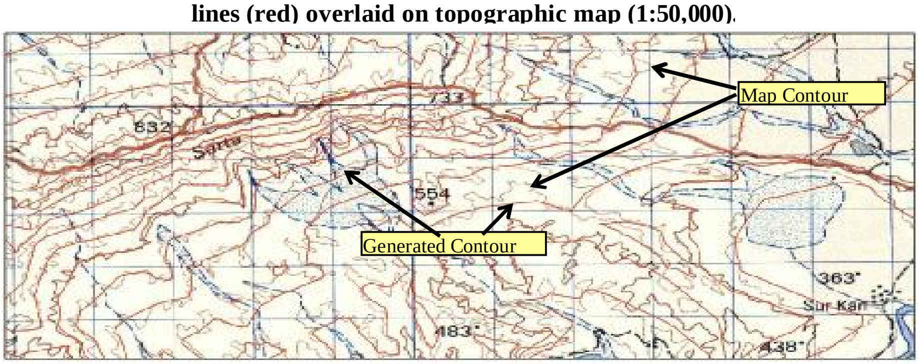


Figure (12) Zoomed part of 3rd test area illustrating the generated GE contour lines (red) overlaid on topographic map (1:50,000).

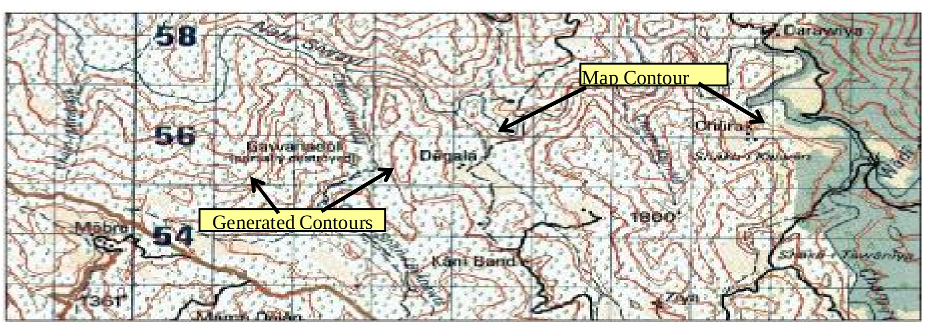


Figure (13) Zoomed part of 4th test area illustrating the generated GE contour lines (red) overlaid on topographic map (1:50,000).